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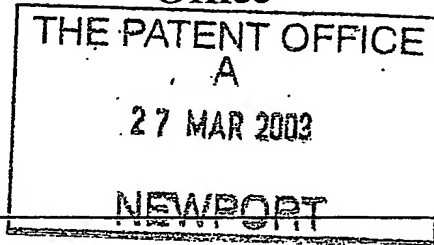
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2.	Patent application number (The Patent Office will fill in this part)	0307055.4			
3.	Full name, address and postcode of the or of each applicant (underline all surnames)	UNILEVER PLC UNILEVER HOUSE, BLACKFRIARS LONDON, EC4P 4BQ			
	Patents ADP number (if you know it)	50426956002			
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM			
4.	Title of the invention	SPRAY GENERATION USING A VIBRATING SURFACE			
5.	Name of your agent (if you have one)	ELLIOTT Peter William			
	"Address for Service" in the United Kingdom to which all correspondence should be sent (including the postcode)	PATENT DEPARTMENT, UNILEVER PLC COLWORTH HOUSE, SHARNBROOK BEDFORD, MK44 1LQ			
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8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))	YES			

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### Priority Documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination and search (*Patents Form 9/77*) 1

Request for substantive examination (*Patents Form 10/77*)

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SPRAY GENERATION USING A VIBRATING SURFACEField of Invention

5

The present invention is in the field of spray technology, in particular, spray technology utilising atomisation from a vibrating surface. The invention relates to a method of producing a high quality spray via atomisation from particular vibrating surfaces; also disclosed are spray devices incorporating such surfaces.

Background

15

Spray devices utilising atomisation from a vibrating surface are known in the art. Such devices may utilise ultrasonic vibrational frequencies and may be used, for example, as nebulizers and asthma inhalers. US 4,702,418 (Carter) discloses the use of an ultrasonic piezoelectric vibrator to generate acoustic vibration. US 5,297,734 (Toda) discloses ultrasonic atomisation from a vibrating plate (attached to a piezoelectric vibrator), said plate having a large number of minute holes through which the liquid to be atomised passes. WO 00/47335 (S. C. Johnson and Son) describes such an atomisation surface as an orifice plate. WO 5,299,739 (TDK Corp.) discloses an atomisation surface with a mesh located in close proximity. Similarly, US 4,796,807 (Lechler GmbH & C.KG) discloses an atomiser comprising an ultrasonic atomising disc with a sieve-like diaphragm resting upon it.

Summary of the Invention

The present invention involves a vibrating atomisation surface that has a particular design. It enables high  
5 quality atomisation to be effectively and efficiently achieved; in particular, it enables operation at relatively low frequencies, thereby reducing the power requirement. Spray devices incorporating such vibrating atomisation surfaces can have numerous benefits, including being easily  
10 portable, potentially battery powered, capable of long periods of use, and producing good quality sprays.

In a first aspect of the present invention, there is provided a method of generating a spray comprising  
15 subjecting a liquid on a continuous atomisation surface to acoustic vibration, characterised in that the continuous atomisation surface comprises multiple hollows from which the liquid is atomised.

20 In a second aspect of the present invention, there is provided a spray device comprising a continuous atomisation surface, a reservoir for holding the liquid to be atomised, means for transferring the liquid from the reservoir to the atomisation surface, and means for subjecting the continuous  
25 atomisation surface to acoustic vibration, characterised in that the continuous atomisation surface comprises multiple hollows from which the liquid is atomised.

In a third aspect of the present invention, there is  
30 provided a product comprising a spray device according to

the second aspect of the invention and a liquid composition for spraying therefrom.

5 Detailed description

Throughout this specification, the term "acoustic vibration" should be understood to refer to vibration at frequencies across the range of the acoustic spectrum. The  
10 acoustic vibration used according to the invention is typically at a frequency of from 1 KHz to 100 KHz, in particular from 2 KHz to 55 KHz, and especially from 5 KHz to 40 KHz. Low range ultrasonic frequencies are particularly preferred, typically values being from 20 to 55  
15 KHz and especially from 20 to 40 KHz.

The novel atomisation surface used as part of the present invention comprises multiple hollows and is continuous, meaning that the atomisation surface comprises no gaps  
20 between elements making up the surface and its multiple hollows. Elements making up the surface may comprise walls and a base, in which case the walls are attached to the base and are preferably integral therewith.

25 In many embodiments, the underlying shape of the atomisation surface is planar, although other shapes such as frusto-conical are possible. The underlying shape of the atomisation surface may be thought of as the surface comprising all of the lowest points of the hollows. When  
30 the underlying shape of the atomisation surface is planar,

the plane may be orthogonal to the acoustic vibration used to create atomisation.

For maximum efficiency of space, it is preferred that the continuous atomisation surface comprises multiple hollows covering 50% or greater, in particular 90% or greater of its area.

The continuous atomisation surface may take the form of a cusp surface in which the surface comprises both multiple hollows and multiple peaks. An example is the cusp surface illustrated in Figure 1.

The continuous atomisation surface may comprise hollows having planar sloping sides. The sloping sides may meet at a line or a point at the bottom of the hollow. An example of the latter are hollows having the form of inverted pyramids, as illustrated in Figure 2.

In many embodiments the continuous atomisation surface may comprise hollows each having walls and a base. Preferably the hollows each have the same depth. For ease of manufacture, it is preferred that the bases are flat. For the same reason, it is preferred that the walls are perpendicular to the base. It is particularly preferred that the hollows have flat bottoms, walls perpendicular thereto, and have the same cross-sectional shape at any depth.

With regard to the preferred cross-sectional shape and maximum cross-sectional dimension of a hollow, these terms

should be understood to refer to the cross-section of a hollow at its top.

5 Preferably, the cross-sectional shape of the hollows is such that the hollows tessellate. This is particularly useful when the hollows have flat bottoms and walls perpendicular thereto.

10 Preferred cross-sectional shapes for the hollows are triangular, square, or hexagonal (as illustrated in Figure 3). Hollows having square or hexagonal cross-section are particularly preferred. It is preferred that all the hollows on the continuous atomisation surface have the same cross-sectional shape.

15 The ratio of the depth of a hollow to the maximum cross-sectional dimension of the same hollow is generally 1:1 or greater, in particular 1:2.5 or greater. Preferably, this ratio is 20:1 or less, more preferably 10:1 or less, and  
20 especially 6.5:1 or less. Generally, this ratio is the same for all of the hollows on the atomisation surface.

The depth of each hollow is preferably 5 mm or less, in particular 2.5 mm or less, and especially 1.5 mm or less,  
25 with a preferred minimum depth of 0.05 mm, in particular 0.1 mm. The maximum cross-sectional dimension of the hollows is preferably from 0.1 mm to 6.5 mm, in particular from 0.2 mm to 3 mm, and especially from 0.5 mm to 3 mm.

30 During use, the hollows on the continuous atomisation surface contain the liquid to be atomised. The amount of



liquid present is preferably 50% or greater, more preferably 90% or greater, and most preferably 99% or greater of the volume of the hollows.

5 Spray devices that operate according to the method of the invention require a reservoir for holding the liquid and a means for transferring the liquid from the reservoir to the atomisation surface. The liquid may be transferred to the atomisation surface from the top or from underneath. In  
10 many embodiments there exists a transfer conduit for transfer of the liquid from the reservoir towards the atomisation surface. The liquid may be fed onto the atomisation surface from a transfer conduit directed onto or opening into the centre of the atomisation surface, the  
15 liquid at first flowing into the hollows nearest the end of the transfer conduit of the transfer conduit and then overflowing from those into adjacent hollows and so on. An example of an atomisation surface designed for transfer of liquid, from underneath, into the centre of the surface is  
20 illustrated in Figure 4A.

When present, the transfer conduit preferably comprises one or more valves. Such valves may function to prevent leakage of the liquid from the reservoir when the device is not  
25 operating. Positive pressure on the reservoir side of the valve or negative pressure on the nozzle side of the valve may cause the opening of such valves.

The means for transferring the liquid from the reservoir to  
30 the atomisation surface may comprise a pump, for example a diaphragm pump, piston pump, or peristaltic pump. Said pump

may act upon the liquid itself or may act as a compressor to  
 pressurise gas in contact with the liquid to be transferred.  
 Alternatively, compressed gas may be introduced into the  
 reservoir during the manufacture of the device and used to  
 5 provide the force required to transfer the liquid to the  
 atomisation surface.

Spray devices that operate according to the method of the  
 invention require a means for subjecting the continuous  
 10 atomisation surface to acoustic vibration. Said means  
 generally functions by being in contact with the atomisation  
 surface and subjecting it to acoustic vibration. Typically,  
 the means comprises a piezoelectric transducer mechanically  
 coupled to an amplitude transformer, the latter element  
 15 being in contact with the atomisation surface. The  
 piezoelectric transducer may be of any of the types known in  
 the art and serves to translate electrical energy from a  
 battery or other such source into mechanical energy of  
 vibration.

20 The battery or other source of electrical energy referred to  
 above may be contained within the device itself, being for  
 example a battery (disposable or rechargeable), a capacitor,  
 or a photoelectric cell, or the source may be external, for  
 25 example mains electricity. Similar sources of electrical  
 energy may be used to power the aforementioned pump, when  
 present, and/or a fan for aiding the flow of atomised liquid  
 from the device towards its target (*vide infra*).

30 The means for subjecting the fluid to acoustic vibration may  
 comprise an activation means. The activation means may be

of any appropriate form. Typical examples include push buttons, toggle switches, or slide-operated switches. The activation will typically involve supply of electrical energy to the aforementioned piezoelectric transducer  
5 mechanically coupled to the amplitude transformer. A pump for transferring the fluid from the reservoir to the atomisation surface and/or a fan for aiding the flow of atomised liquid from the device towards its target (*vide*  
10 *infra*) may also be activated on use of the activation means, in the presence of appropriate circuitry.

An additional component that may be used in spraying devices according to the present invention is a means of generating airflow adjacent to the upper side of the atomisation  
15 surface. Such airflow may enhance the delivery of the spray generated from the atomisation surface. A fan is a suitable means of generating the airflow and may be incorporated into the spraying device in a manner that enables generation of airflow adjacent to the upper side of the atomisation  
20 surface. The use of a fan in an acoustic atomiser is described in US 3,970,250 (Siemens Aktiengesellschaft).

An inlet vent for air is a preferred additional feature of devices according to the present invention, in particular  
25 those also comprising a means of generating airflow adjacent to the upper side of the atomisation surface.

A spraying device according to the present invention is able to achieve high fluid output, for example from 30 ml/hr. to  
30 500 ml/hr., and, in particular, from 45 ml/hr. to 180 ml/hr., whilst still maintaining good spray quality. Spray

quality may be defined by the fineness of the droplets achieved and/or by the narrowness of the particle size distribution of said droplets. For many applications, it is desirable to achieve a particle size distribution in which the D<sub>4,3</sub> droplet volume size is from 1  $\mu\text{m}$  to 150  $\mu\text{m}$ , in particular from 5  $\mu\text{m}$  to 100  $\mu\text{m}$ , and especially from 5  $\mu\text{m}$  to 25  $\mu\text{m}$ . The narrowness of particle size distribution may be expressed by the "SPAN", where SPAN is  $[D(90)-D(10)]/D(50)$ . The present invention preferably operates to give a SPAN of 1.2 or less, in particular 1.0 or less, and especially 0.9 or less.

The spraying device of the present invention is preferably hand-held. The device and the method of spray generation is particularly suitable for use in the domestic environment, i.e. in the home and garden. The device may be used with numerous liquid compositions, in particular compositions for use in the domestic environment, such as cleansing and perfuming compositions. It is especially suitable for application of liquid cosmetic compositions, which are generally applied directly to the human body. Examples of such compositions include hair sprays, perfume sprays, and deodorant sprays (body sprays and underarm products, in particular antiperspirant compositions).

Liquid compositions used with the device of the present invention typically comprise a liquid carrier. The liquid carrier may comprise a C<sub>2</sub> to C<sub>4</sub> alcohol, for example ethanol, propylene glycol, propanol, or iso-propanol. When such liquid compositions are cosmetic compositions for application to the human body, the good spray quality

- 10 -

attained leads to an excellent sensory benefit for the user. Suitable liquid compositions typically comprise C2 to C4 alcohol at a level of from 5% to 95%, in particular from 25% to 80%, and especially from 40% to 75% by weight of the composition. Liquid compositions comprising ethanol are particularly suitable for use with the device of the present invention.

The aforementioned liquid carrier may also comprise water in an amount from 0.1% to 99% by weight of the composition.

Embodiments according to the present invention are described more fully by way of example only and with reference to the accompanying drawings, in which:

15

Figure 1 is a representation of a continuous atomisation surface having a cusp hollows;

20

Figure 2 is a representation of a continuous atomisation surface having hollows with planar sloping sides meeting at a point and having the form of inverted pyramids;

25

Figure 3 is a representation of a continuous atomisation surface having hollows with flat bases and perpendicular sides, the hollows having a hexagonal cross-section;

Figure 4 is a central vertical section through a specific embodiment of a spraying device according to the present invention.

30

Figure 4A is a top view of a central portion of the embodiment represented in Figure 4 (scale increased).

In the embodiment represented by Figure 4, a continuous  
5 atomisation surface (1) is present on the top surface of an  
amplitude transformer (2), which amplifies ultrasonic  
vibration originating from a piezoelectric transducer (3).  
The piezoelectric transducer (3) comprises two annular  
piezoelectric discs (4A, 4B), having sandwiched between them  
10 an input electrode (5). Below the piezoelectric discs (4A,  
4B) is a support block (6), with an earth electrode (7)  
sandwiched between the lower piezoelectric disc (4B) and the  
support block (6). The input electrode (5) receives power  
from a battery (8), via an electrical supply conduit (9) and  
15 the earth electrode (7) is earthed to an outer casing (10)  
via an earthing conduit (11).

Surrounding the piezoelectric discs (4A, 4B), electrodes (5,  
7), and support block (6), there is an inner casing (12).  
20 The base (13) of the amplitude transformer (2) is located in  
the top section of the inner casing (12). A small gap (14)  
between these components is sealed by means of an o-ring  
(15). The outer casing is attached to the inner casing (12)  
by support members (not shown).

25

Beneath the inner casing (12), there is a reservoir (16) for  
liquid cosmetic composition (17) and compressed gas (18). A  
transfer conduit, in the form of a plastic tube (19),  
including a dip tube (20), links the reservoir (16) with the  
30 atomisation surface (1). The tube (19) delivers to the  
centre of the atomisation surface (1). The tube (19) passes

through the centre of the device, going through the lower part of the inner casing (12), the support block (6), the earth electrode (7), the lower piezoelectric disc (4B), the input electrode (5), the upper piezoelectric disc (4A), and the amplitude transformer (2), en route to the atomisation surface (1).

An electrically operated valve (21) serves to hold the pressurised liquid (17) in the reservoir (16) until operation of the device is desired.

Beneath the reservoir (16) there is a fan (22), driven by fan motor (23). This fan serves to generate airflow, this airflow being adjacent to the upper side of the atomisation surface at the top of the device. The air enters the device through vents (24) in the outer casing (10) and, in passing through the device, passes through baffles (25), which serve to smooth the flow of the air over the atomisation surface (1).

All of the electrical power for the device is supplied by the battery (8), which can be accessed via a detachable plate (26) in the bottom section of the outer casing (10). Power supply from the battery (8) is activated by means of pressure switch (27). Control circuitry, not shown, connects all the electrical components of the device. When the device is activated by pressing switch (27), power is supplied from the battery (8) and the electrical valve (21) is opened, the piezoelectric discs (4A, 4B) are activated, and the fan motor (23) is activated.

Figure 4A shows the atomisation surface (2), which has a regular array of tessellating hexagonal cross-section hollows upon it. Opening into the centre of the atomisation surface is the transfer conduit (19).

5

### Experiments

Various atomisation surfaces were tested. Acoustic vibration was provided by a variable frequency signal generator (type J2B, Advance), together with a 120 watt amplifier (type Prism Audio MTK 150F), feeding in to a 300 watt loudspeaker (type Rc92, Delta 10A, 10 Inch PA driver), upon which the atomisation surfaces were placed. The quality of the spray produced was analysed using a Malvern 2600 laser diffraction instrument.

15

20

Table 1 gives spray data generated from atomisation surfaces having hollows having flat bottoms, perpendicular sides, and hexagonal cross-sections, as illustrated in Figure 3. The hexagonal hollows of each atomisation surface were of the same dimensions, these also being indicated in the Table. The hollows were kept full of the indicated liquid during the course of the experiments.

25

30



Table 1: Examples 1 to 6

Example	Acoustic Frequency (KHz)	Hexagonal hollow dimensions (mm)		Liquid atomised	Spray quality	
		side	depth		D4,3 ( $\mu$ )	SPAN
1	5	2.5	1.5	Water	138.5	0.36
2	5	2.5	1.5	Ethanol	113.2	0.46
3	5.5	2.5	1.5	Water	150.8	0.51
4	5.5	2.5	1.5	Ethanol	138.6	0.68
5	6.5	5.0	1.5	Water	49.6	0.70
6	6.5	5.0	1.5	Ethanol	82.6	0.82

The Table indicates good quality spray generation (note, in particular, the low SPAN values) at relative low acoustic frequencies. In a comparative experiment, the spray quality from a commercially available Lechler ultrasonic atomiser (US2710) was measured. At an acoustic frequency of 58 KHz the spray produced had a D4,3 of 97.0  $\mu$  and a SPAN of 1.37 - i.e. lower quality than the Examples according to the invention, despite the significantly higher acoustic frequency used.

CLAIMS:

1. A method of generating a spray comprising subjecting a liquid on a continuous atomisation surface to acoustic vibration, characterised in that the continuous atomisation surface comprises multiple hollows from which the liquid is atomised.
2. A method according to claim 1, wherein the multiple hollows cover 50% or greater of the atomisation surface.
3. A method according to claim 1 or 2, wherein the depth of each hollow is 5 mm or less.
4. A method according to any of the preceding claims, wherein the hollows tessellate.
5. A method according to any of the preceding claims, wherein the hollows have the same cross-sectional shape.
6. A method according to any of the preceding claims, wherein the continuous atomisation surface comprises multiple hollows having hexagonal cross-sectional shape.
7. A method according to any of claims 1 to 5, wherein the continuous atomisation surface comprises multiple hollows having square cross-sectional shape.

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8. A method according to any of claims 2 to 7, wherein the hollows cover 90% or greater of the atomisation surface.
- 5 9. A method according to any of the preceding claims, wherein the hollows have vertical walls.
10. A method according to any of the preceding claims, wherein the hollows have flat bottoms.
- 10 11. A method according to any of the preceding claims, wherein the liquid to be atomised is present in the hollows at an amount of 50% or greater of the volume of the hollows.
- 15 12. A method according to any of the preceding claims, wherein the acoustic vibration is at frequency of from 2 to 55 KHz.
- 20 13. A method according to any of the preceding claims, for the generation of a spray in the domestic environment.
14. A method according to claim 12 or claim 13, for the generation of a cosmetic spray.
- 25 15. A method according to claim 14, for the generation of a deodorant spray.
- 30 16. A spray device comprising a continuous atomisation surface, a reservoir for holding the liquid to be atomised, means for transferring the liquid from the

reservoir to the atomisation surface, and means for  
subjecting the continuous atomisation surface to  
acoustic vibration, characterised in that the  
continuous atomisation surface comprises multiple  
5 hollows from which the liquid is atomised.

17. A spray device according to claim 16, wherein the means  
for subjecting the liquid to acoustic vibration  
comprises an acoustic vibrator which is in contact with  
10 the underside of the atomisation surface and a control  
means for activating the acoustic vibrator.

18. A spray device according to claim 16 or 17, wherein the  
continuous atomisation surface comprises multiple  
15 hollows having a hexagonal cross-section.

19. A spray device according to any of claims 16 to 18,  
wherein the means for delivering a liquid to the  
atomisation surface enables supply of the liquid from  
20 the underside of said atomisation surface.

20. A spray device according to any of claims 16 to 19,  
comprising a means of generating airflow adjacent to  
the upper side of the atomisation surface.

25

21. A product comprising a spray device according any of  
claims 16 to 20 and a liquid cosmetic composition for  
spraying therefrom.

- 21 -

Abstract

5 A method of generating a spray comprising subjecting a liquid on a continuous atomisation surface to acoustic vibration, characterised in that the continuous atomisation surface comprises multiple hollows from which the liquid is atomised.

Figure 1

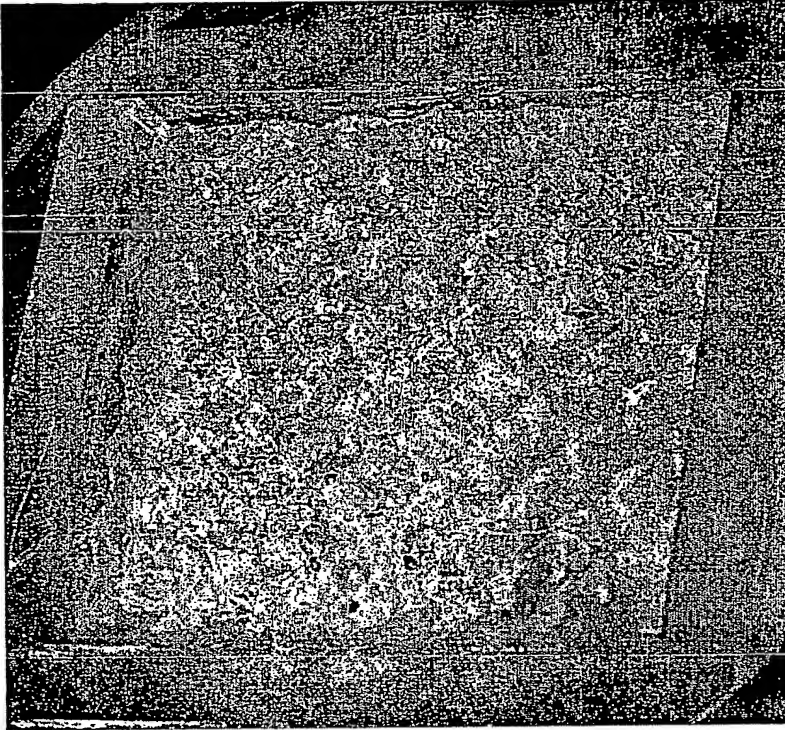
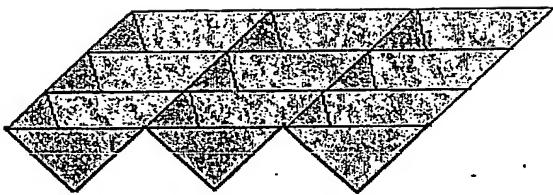


Figure 2



5 Figure 3

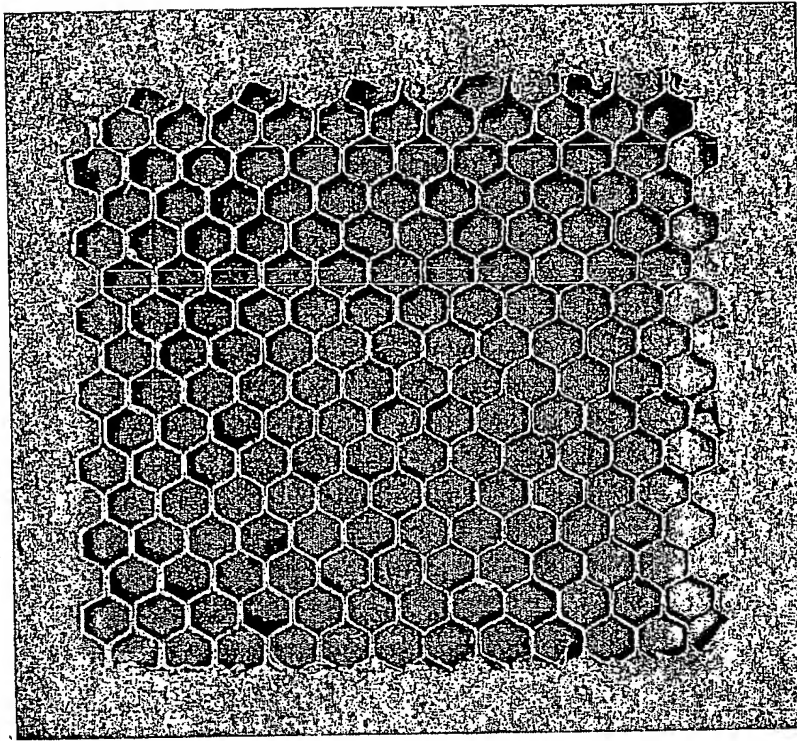


Figure 4

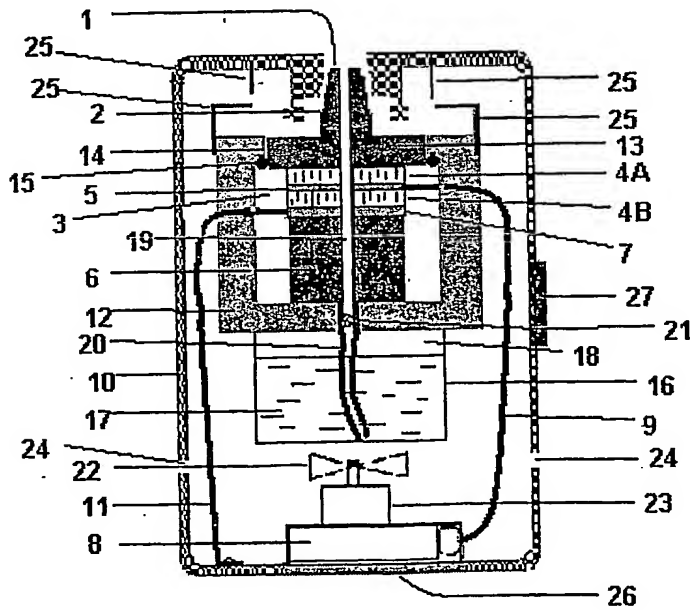
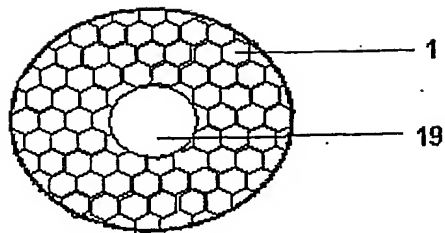
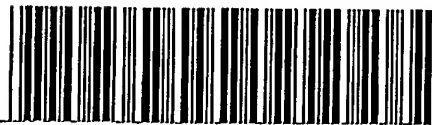


Figure 4A





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